Mathematics 172

Quiz #3 Name: Key

You must show your work to get full credit.

A cell has volume $V = 5.2 \times 10^{-6}\text{mm}^3$ and surface area $A = 7.5 \times 10^{-3}\text{mm}^2$. Assume that oxygen, O_2, passes through the cell membrane at a rate of $.38(\text{mg/mm}^2)/\text{hr}$.

1. What is the total amount of O_2 that is coming into the cell per hour?

Amount of O_2/hour is .00285 mg/hr $= 2.85 \times 10^{-3}$ mg/hr

Amount = (Amount/Area) × Area
= (rate) × Area
$= (.38)(7.5 \times 10^{-3})((\text{mg/mm}^2)/\text{hr}) \times \text{mm}^2$
= .00285 mg/hr

2. What is the amount of O_2 per volume coming into the cell per hour?

Amount of O_2 per volume per hour is 548.1 (mg/hr)/mm³

This is (Amount)/Volume $= \frac{.00285}{5.2 \times 10^{-6}} \frac{\text{mg}}{\text{hr}} \frac{1}{\text{mm}^3}$
$= 548.1\ (\text{mg/hr})/\text{mm}^3$

3. If the cell needs $58(\text{mg/mm}^3)/\text{hr}$ of O_2 to survive, then how much can it be magnified before it dies from lack of oxygen?

Let λ = magnification factor
= scale factor

9.45

magnified volume $= 5.2 \times 10^{-6} \lambda^3\ \text{mm}^3$
magnified Area $= 7.5 \times 10^{-3} \lambda^2\ \text{mm}^2$
Amount of O_2/hr $= (.38)(7.5 \times 10^{-3} \lambda^2) = .00285 \lambda^2$ mg/hr
(Amount of O_2/hr)/vol $= \frac{.00285 \lambda^2}{5.2 \times 10^{-6} \lambda^3} = \frac{548.1}{\lambda}\ (\text{mg/mm}^3)/\text{hr}$

So we want to solve

$$\frac{548.1}{\lambda} = 58$$

so $\lambda = \frac{548.1}{58} = 9.45$